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ABSTRACT

The usefulness of a holistic model designed for Indonesia in explaining the predictive relationship between student background characteristics and college academic achievement was assessed. The model consists of four constructs (cognitive entry behavior, attribution of success and failure, socioeconomic status, and family educational environment) as well as measurable variables for the constructs. The study population consisted of 411 Indonesian students preparing to be technical teachers in five technology areas in two institutes, one that recruits students primarily from rural to suburban settings and the other that recruits from urban to suburban settings. Results of path analysis and covariance structural analysis are presented. The model strongly predicted college academic achievement, accounting for 70% of the variance. It was less efficient in accounting for cognitive entry behavior or attribution of success and failure. The model and empirical evidence showed the importance of cognitive entry behavior, socioeconomic status, family educational environment, and attribution of success and failure. Information on the Indonesian education system is included. (SW)

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HOLISTIC MODEL FOR PREDICTING ACADEMIC SUCCESS

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HOLISTIC MODEL FOR PREDICTING ACADEMIC SUCCESS

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Interest in the relationship between student background characteristics and academic achievement has existed for seven decades. In several respects, Lincoln's study in 1917 established parameters for this line of inquiry. Subsequently, distinctive research developed which drew upon the tenets of separate disciplines.

One line of investigation, associated with the discipline of psychology and eventually educational psychology, focused on the relationship between student ability and achievement. Benjamin Bloom (1976) is a contemporary advocate of this line of reasoning and his peers include Bowles, 1970 and Brubaker, 1976. While this psychological perspective includes cognition, it also encompasses affective behavior (Bloom, 1964) and attributional factors (Weiner, et al., 1971).

Sociology contributed a second major focus of investigations. An obvious proponent of this perspective was Coleman (1966) with his keystone investigations of socioeconomic factors and school achievement. Coleman peers include Blau and Duncan (1967), Kohn (1969), Blalock (1980), and Mercy and Steelman, 1982.

Substantial evidence supports the association of both psychological and sociological variables with academic

achievement. However, predictive models seldom incorporated factors from both disciplines. At least two researchers believe the limiting effect of statistical models and their attendant assumptions has been responsible for this deficiency (Joreskog & Sorborm, 1979). However, advances in statistical methods, including the LISERAL technique, have provided encouraging new possibilities to investigators (Joreskog & Sorbom, 1984).

Thus, the capacity to investigate a predictive relationship between selected student background characteristcs (i.e., psychological and sociological variables) and academic achievement was promising and realistic in 1984.

The study reported in this paper, was grounded in practical considerations, as well as an extension of behaviorial research. While Indonesia is one of the world's largest countries (5th in terms of population), it was still considered a developing nation. The country was changing rapidly toward a more technologically oriented society. This rapid change required efficiency and effectiveness in the teacher training arena, which operationally became the need for improvement in admission criteria to the technical institutes. Specifically, a clearer understanding about background characteristics and academic achievement was needed for students preparing to be teachers of technical/vocational subjects.

The population's rather narrow focus and the language translations posed additional worries and design considerations. However, the potential practical application of the findings were an important force.

Therefore, the study was rooted in two needs: (a) better understanding of the predictive relationship between student background characteristics and college level academic achievement and (b) the practical application of a predictive model to higher education admission practices.

Purpose

The study's purpose was to investigate the extent to which the interrelationship among student background characteristics (data) were explained by a holistic predictive model designed for Indonesia.

The problem emphasized the deductive development of the model, which drew upon predictive theories, and the testing of it against actual conditions.

Model

Psychologists and many educators maintain that academic achievement can best be predicted by student cognitive entry behavior (Bloom, 1976) and the attribution of success and failure (Weiner, 1974). Whereas, sociologists believe that family educational environment (Jenks, et al., 1972 and Williams, 1976) and family socioeconomic status (Blau & Duncan, 1967) are critical mediating factors affecting students' academic achievements. These four major constructs emerged from the literature. Thus, the model combined the most powerful

variables within the constructs for predicting academic success. These variables are depicted in Table 1.

Table 1

Latent and Measurable Variables Conceived as Potential Predictive Factors

Latent Variable	Measurable Variable
Cognitive entry behavior	High school grade point average Admission criteria (test & rank)
Attribution of success & failure	Ability Effort Task difficulty Luck
Socioeconomic status	Father's educational level Mother's educational level Family size Family income
Family educational environment	Stimuli Reinforcement Expectation

The four constructs appeared to be distinct and autonomous factors which encompassed several measurable variables. These constructs, all grounded in theories, were subsumed under the broad term "student background characteristics," and included: (a) cognitive entry behavior, (b) attribution of success and failure, (c) family educational environment, and (d) family socioeconomic status. The four constructs were conceived as latent variables. By definition a latent variable was not a directly observable behavior. However, these constructs

included variables which could be measured and thus create the intended construct.

The criterion measure was named college academic achievement. This criterion, a latent variable, included two observable variables, both measures of college achievement. These intermediate measures of success were: (a) pedagogy grade point average (pedagogy GPA) and engineering grade point average (engineering GPA).

The simplified model displays the possible interrelationship of variable, latent and observable, and the criterion measure. A graphic depiction of the model appears in Figure 1. The same model, complete with LISERAL statistic notations, is included in Appendix A.

Procedures

Since the study applied to Indonesia, the data collection was conducted in that country. All other procedures were carried out in the United States.

Population. The population included Indonesia students preparing to be technical teachers in five technology areas of two institutes. While there were 10 technical teacher training faculties, the decision was made to limit the population to two institutes with students representing a broad cross section of socioeconomic characteristics. The first institute, Padang, recruits students primarily from rural to surburban settings while Yogyakarta recruits from urban to surburban settings.

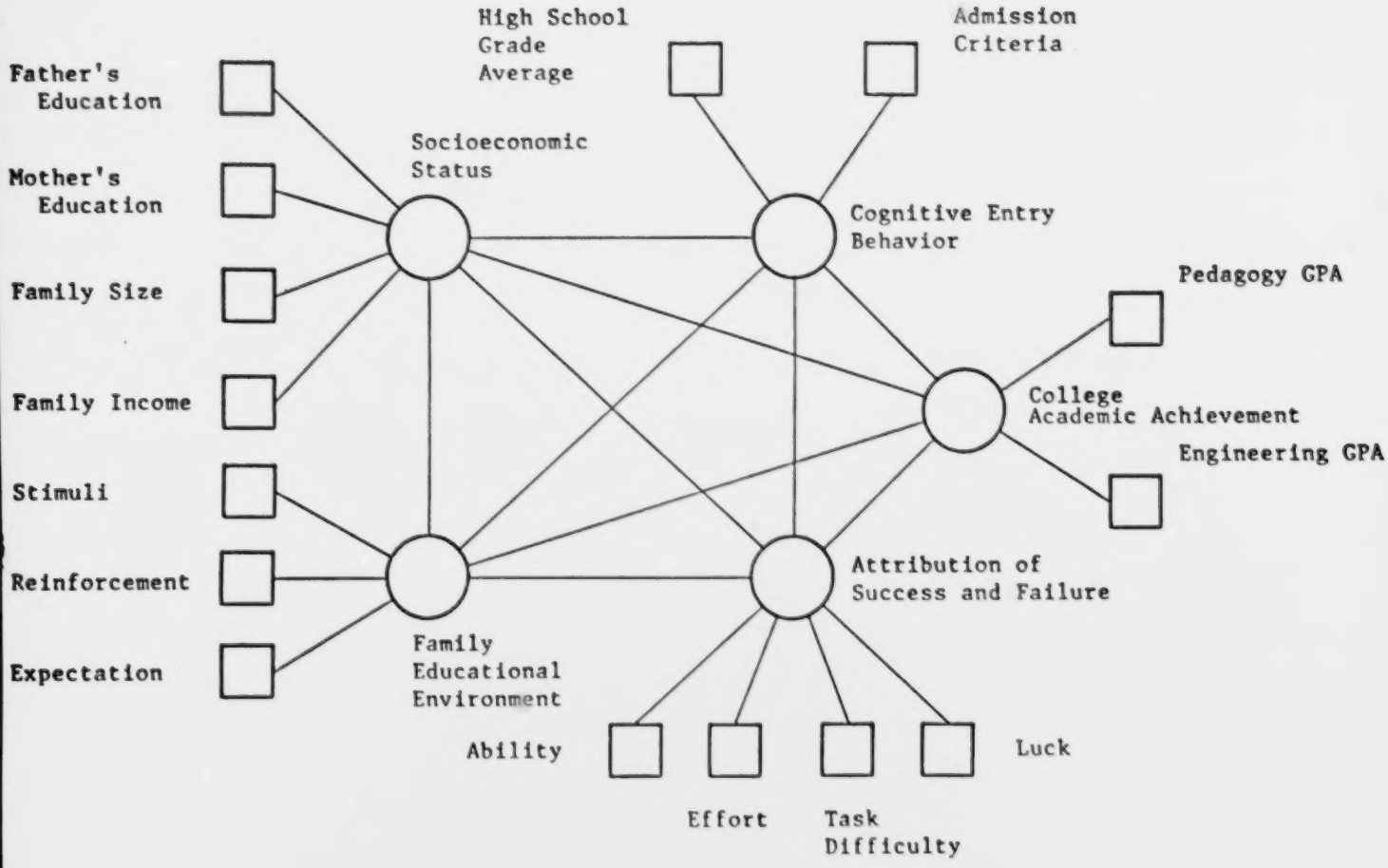

Figure 1. Model of Predicting College Achievement from Student Background Characteristics

These institutes were established by the government as model programs to demonstrate and test the institute concept. A graphic presentation of Indonesia's educational system appears in Appendix B.

Sample. A stratified random sample was drawn. The student sample consisted of 71% from Padang and 29% from Yogyakarta. These figures agree with the percent of rural to urban population, respectively. The total sample included 411 students. The sample was also stratified by technical (engineering) major. The type of engineering major was important to assure nonbias by technical skill areas. Table 2 provides a perspective on the sample distributed by major and school year.

Table 2

Distribution of Students by Major and College Standing

Major	College Standing (Year) 2nd	3rd	4th	Row Total
Mechanical	14	38	55	107
Automotive	5	21	37	63
Building	20	7	66	93
Electrical	11	13	58	82
Electronic	11	18	37	66
Column Total	61	97	253	411

Instrument. The instrument was complex and diverse. In some instances, the necessary data to operationalize a variable were readily available in the students' academic records. Definitions for all variables appear in Appendix C. Other items simply required completing an open response option (e.g., "How many people do your parents support for living?") or a multiple choice option (e.g., "My college standing is: 2nd year, 3rd year, 4th year). Some information was provided to the students in the form of a print out from the institute's official records. Thus, all items in the instrument were designed to facilitate students' responses at one administration of the instrument.

Two latent variables were more complex to operationalize. The instruments required translation and revalidation to asure consistency between the constructs in English and Indonesian. The latent variables included: (a) family educational environment and (b) attribution of success and failure.

After the instruments' items were translated from English versions, and in some cases modified to be consistent with expected Indonesia folkways, a panel of 15 judges, Indonesian students in America, classified the items. Judges were provided with definitions of all latent and operational variables. Criteria were established for retaining items and variables. These criteria included 80% agreement on the total construct and 64% agreement on the subclassifications.

Once the instrument was administered, a reliability measure (i.e., internal consistency) and factor analysis with varimax

rotation were computed. Reliability indices and the concurrent validity measures are presented in Table 3. The validity index compared empirically derived factors with logically classified factors.

Table 3

Reliability and Concurrent Validity of Two Latent Variables

Latent Variables	Reliability Alpha	Empirical Factors	% of Criteria(*)
Family educational environment	.79	3	100%
Attribution: success & failure	.53	4	100%

(*) % of criteria represents the level of agreement between the 15 judges' rating of the subclassification and the factors derived through factor analysis.

Data collection. Data were collected by a team of three administrators, two at Padang and one at Yogyakarta. They received training and actually completed the instrument as a basis for understanding the procedures. The instrument, in Indonesian, was prepared in booklet form with an optical scanning response form. Essential records developed by the registrars were given to students who transferred the information to the response form. The administration of the instrument required 10 sessions conducted during late July and early August 1984. These procedures produced 382 (92%) fully answered response forms.

Data analysis. The data analysis was conducted in two sequencial steps: path analysis and covariance structural analysis with latent variables (see Figure 2). The former statistical technique was used to analyze the covariance structural model with direct observable variable (NIE, et al., 1975) and the latter analyzed the covariance structural models with indirectly observable or latent variable (Joreskog & Sorbom, 1984).

A basic concept of path analysis was the comparison of two estimates: unweighted least squares and maximum likelihood. If there was no significant difference between the two types of estimates, the results were considered a true value. Information from the path analysis was used later to facilitate the LISREL analysis of indirectly observable variables.

Findings

The study's objective was to test the model's theoretical constructs of student background characteristics and college achievement against appropriate data. The results of the main hypothesis tested through path analysis are presented first. Later, an examination of the same hypothesis through latent variables, using covariance structural analysis, will be discussed. The working hypothesis of this study was:

> There is no significant difference between the effect of socioeconomic status, family educational environment, cognitive entry behavior, and students' attribution of success and failure on students' college academic achievement with respect to two teacher training institutes in Indonesia.

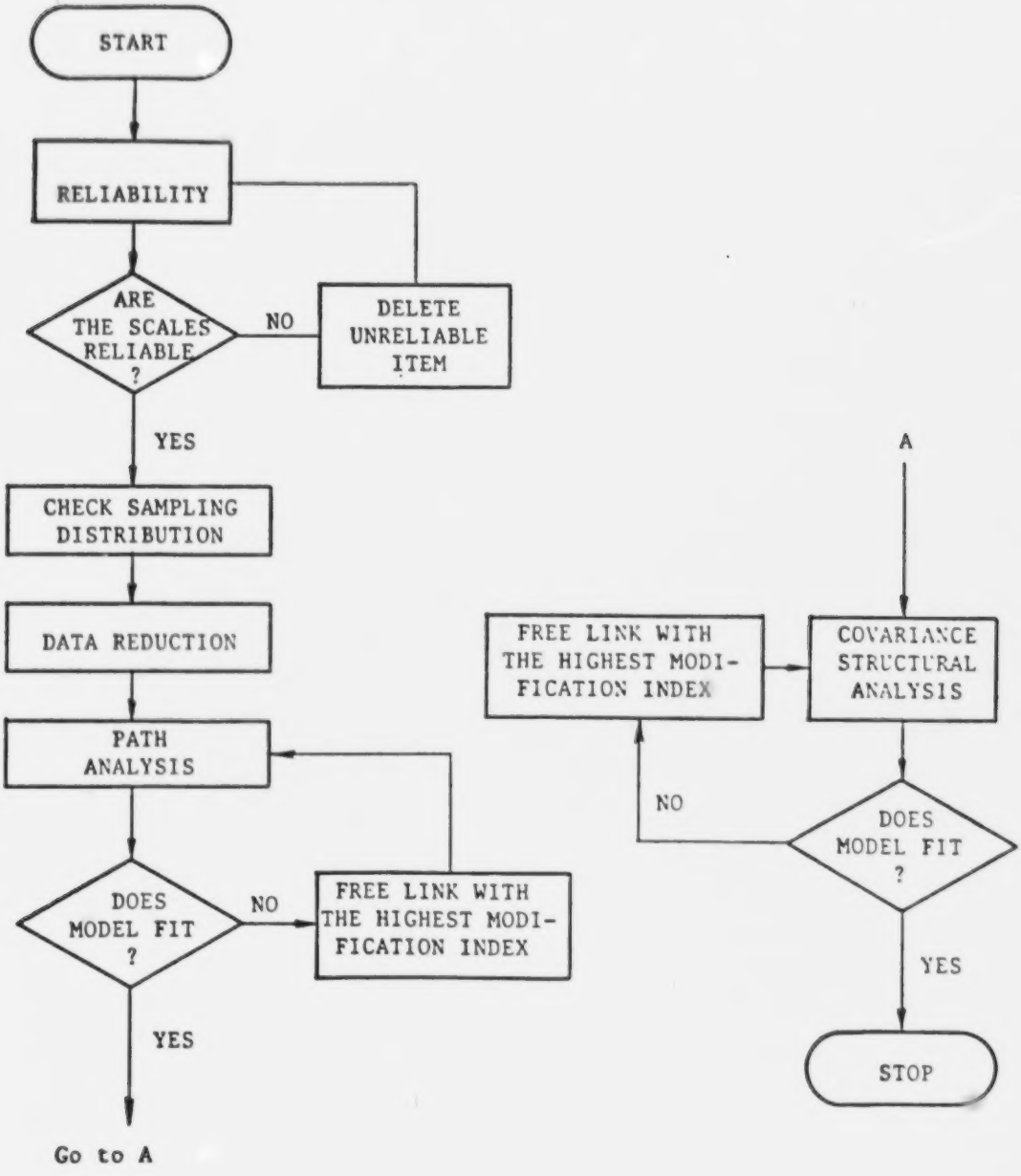

Figure 2. Flow Chart of Data Analysis

The main hypothesis of the study was translated into the following null hypothesis:

> There is no significant difference between the correlation matrix produced by the model (population matrix Σ) and data (sample matrix S of student background characteristics and college academic achievement scores of Padang and Yogyakarta institute students).

The null hypothesis was tested on the basis of five criteria suggested by Joreskog and Sorbom (1984): (a) parameter estimates, (b) standard error, (c) squared multiple correlation, (d) coefficient of determination, and (e) correlation of parameter estimates when maximum likelihood estimation was conducted.

Path Analysis

Parameter estimates are presented in Table 4. It was clear from an inspection of this table that there was no significant difference between the two methods of estimation: unweighted least square (ULS) and maximum likelihood (ML). Parameters which were estimated higher by unwweighted least square method were typically estimated higher by the maximum likelihood method. There was no qualitative differences in the direction of effect (postive or negative) between ULS and ML. Both methods of estimation gave approximately the same results. Therefore, these features of the data argue that the parameters have been estimated correctly.

There were no unreasonable values such as negative variance, a correlation larger than one in magnitude, or a sample correlation matrix which was not "positive definite." All standard errors were positive and all square multiple

Table 4

Comparison Between Unweighted Least Square (ULS) and Maximum Likelihood (ML) Estimations for Path Analysis

Predictor Variable	Criterion Variable	Value ULS	Value ML	SE
Ability	HSGA	.105	.103	.109
Task difficulty	HSGA	-.061	-.265	.659
Effort	HSGA	.160	.156	.135
Luck	HSGA	.092	.206	.224
HSGA	Admission criteria	-.094	-.181	.050*
Ability	Admission criteria	-.200	-.246	.052*
Task difficulty	Admission criteria	-.094	-.102	.054
Effort	Admission criteria	.046	.049	.051
Luck	Admission criteria	.054	.131	.052*
Father's education	HSGA	.182	.260	.211*
Mother's education	HSGA	.207	.215	.100*
Family income	HSGA	-.072	-.095	.063
Family size	HSGA	.014	-.008	.049
Reinforcement	HSGA	-.032	-.055	.063
Expectation	HSGA	-.056	-.089	.054
Father's education	Admission criteria	.128	.192	.065*
Mother's education	Admission criteria	.246	.288	.068*
Family income	Admission criteria	-.016	-.042	.048
Family size	Admission criteria	-.066	-.102	.047*
Reinforcement	Admission criteria	-.086	-.096	.048*
HSGA	Task difficulty	-.061	.128	.581
Ability	Task difficulty	.221	.138	.061*
Effort	Task difficulty	.191	.178	.077
Luck	Task difficulty	.334	.317	.082*
Ability	Effort	.304	.313	.050*
Luck	Effort	.206	.180	.047*
Ability	Luck	.202	.216	.051*
Father's education	Ability	.266	.363	.060*
Mother's education	Ability	-.006	-.098	.060
Family income	Ability	.066	.060	.048
Father's education	Task difficulty	.200	.283	.113*
Mother's education	Task difficulty	-.021	-.154	.154
Family income	Task difficulty	-.066	-.051	.064
Family size	Task difficulty	.002	.013	.046
Reinforcement	Task difficulty	-.033	-.043	.065
Father's education	Effort	-.109	-.185	.062*
Mother's education	Effort	-.062	.012	.059
Family income	Effort	.056	.036	.047
Father's education	Luck	-.092	-.173	.064*
Mother's education	Luck	-.052	-.013	.063
Family income	Luck	.011	.022	.051
Family size	Luck	.132	.108	.050*

*Mean $p < .05$

Table 4 (continued)

Comparison Between Unweighted Least Square (ULS) and Maximum Likelihood (ML) Estimations for Path Analysis

Predictor Variable	Criterion Variable	Value ULS	Value ML	SE
HSGA	Pedagogy GPA	.354	.461	.045*
Admission criteria	Pedagogy GPA	.340	.437	.044*
Ability	Pedagogy GPA	.138	.213	.047*
Task difficulty	Pedagogy GPA	-.008	.115	.048*
Effort	Pedagogy GPA	.236	.132	.045*
Luck	Pedagogy GPA	-.078	-.203	.046*
HSGA	Engineering GPA	.447	.565	.034*
Admission criteria	Engineering GPA	.409	.550	.034*
Ability	Engineering GPA	.145	.229	.036*
Task difficulty	Engineering GPA	-.112	-.084	.037*
Effort	Engineering GPA	.337	.313	.034*
Luck	Engineering GPA	-.066	-.170	.035*
Father's education	Pedagogy GPA	-.096	-.238	.058*
Mother's education	Pedagogy GPA	-.093	-.202	.055*
Family income	Pedagogy GPA	-.039	.021	.042
Family size	Pedagogy GPA	-.024	.031	.042
Reinforcement	Pedagogy GPA	-.065	-.014	.051
Stimuli	Pedagogy GPA	.019	-.028	.047
Expectation	Pedagogy GPA	.061	.127	.047*
Father's education	Engineering GPA	-.120	-.180	.045*
Mother's education	Engineering GPA	-.121	-.288	.048*
Family income	Engineering GPA	.028	.089	.032*
Family size	Engineering GPA	-.015	.033	.032
Reinforcement	Engineering GPA	-.100	-.111	.039*
Stimuli	Engineering GPA	.064	.054	.036
Expectation	Engineering GPA	.035	.111	.036*
Residual				
High school grade average		.828	.824	.149*
Admission criteria		.889	.829	.058*
Ability		.887	.893	.063*
Task difficulty		.703	.745	.228*
Effort		.806	.847	.066*
Luck		.883	.938	.066*
Pedagogy GPA		.710	.644	.045*
Engineering GPA		.580	.376	.027*
Sum square correlation				
High school grade average		.164	.158	
Admission criteria		.110	.171	
Ability		.083	.107	
Task difficulty		.292	.256	
Effort		.163	.153	
Luck		.061	.062	

*Mean $p < .05$

Table 4 (continued)

Comparison Between Unweighted Least Square (ULS) and Maximum Likelihood (ML) Estimations for Path Analysis

Predictor Variable	Criterion Variable	Value ULS	Value ML	SE
Pedagogy GPA		.298	.360	
Engineering GPA		.456	.627	
Coefficient determination of structural equation		.398	.583	

Chi-square: Df=16 = 13.98, $p > .60$
Goodness of Fit Index = .996
Adjusted Goodness of Fit Index = .966
Mean Root Square Residual = .05

correlations were estimated to be less than one. The goodness of fit index (GFI) was .996. "Goodness of fit" is an index of the relative amount of variances and covariances jointly accounted for by the model" (Joreskog and Sorborm, 1984, p. I-41). Chi-square was found to be compatible with the data (df=16) = 13.98, $p > .60$.

In short, after inspecting the behavior of the parameter estimates, either by using unweighted least square or by using maximum likelihood, the parameters were judged to have been estimated correctly. Since there was no difference between the two methods of estimations and the goodness of fit index was high, the model fit the data on the criterion of parameter estimation very well.

Standard error. The second step in examining the null hypothesis involved the standard error of each parameter estimate of maximum likelihood, also shown in Table 4. No

unreasonable value (i.e., negative or extremely large) in the standard error of parameter estimates was found.

In order to identify the effect of parameter estimates, the confidence interval of 1.96 standard error (for $p < .05$) was used. The ratio between the maximum likelihood parameter estimate and standard errors larger than 1.96 in magnitude are normally judged to be different from zero. Using this criterion thirty-nine significant parameters were found out of 68 parameter estimates. This information on standard error further confirms the model's fit to the data.

Square multiple correlation and coefficient of determination. Both the square multiple correlation and coefficient of determination were positive, which was an indication of good agreement with the model. Root mean square residual (RMR), a measure for averaging residual variance and covariance, was found to be .05. In other words, the goodness of fit index and RMR were sound measures of the overall fit of the model to the data.

Coefficient of correlation among parameter estimates. This index was low, which indicated that each parameter represented a unique variable.

Thus, it can be stated with confidence that the model appropriately fit the data and met all the requisite attributes for testing the null hypothesis. The five criteria above had been fulfilled, which meant that the model's observable variables for predicting pedagogy and engineering GPA were applicable in the Indonesian setting.

To find which estimates were significant, the data given in Table 4 for estimation of parameters were used. Thirty-nine out of 68 parameter estimates were found to be significant. And a significant effect existed for 12 out of 13 observable variables. All significant relationships among student background characteristics are displayed in Figure 3.

Based on path analysis, the model was modified. The variable "stimuli" did not have a significant effect in predicting either the pedagody or engineering GPA. Therefore, it was eliminated from subsequent analyses. Also, the latent variables of family educational environment and socioeconomic status were combined. The resulting latent variable was titled "home condition." These changes followed the plan of using the most effective variables to assure a parsimonious model.

Findings form Covariance Structural Analysis

The same null hypothesis was tested with the modified model. Thus, three criteria remained the same: (a) parameter estimates, (b) square multiple correlations, and (c) coefficient of determinations. Parameter estimates with unweighted least square estimation are given in Table 5. These values were not unreasonable (i.e., the square multiple correlation and residual were not negative or larger than one).

The determinant of the sample correlation matrix was found to be .3502. Thus, the determinant of the sample correlation maxtrix was "positive definite," indicating that the data were appropriate for a covariance structural model. Since the value was very small relative to the magnitude of the diagonal

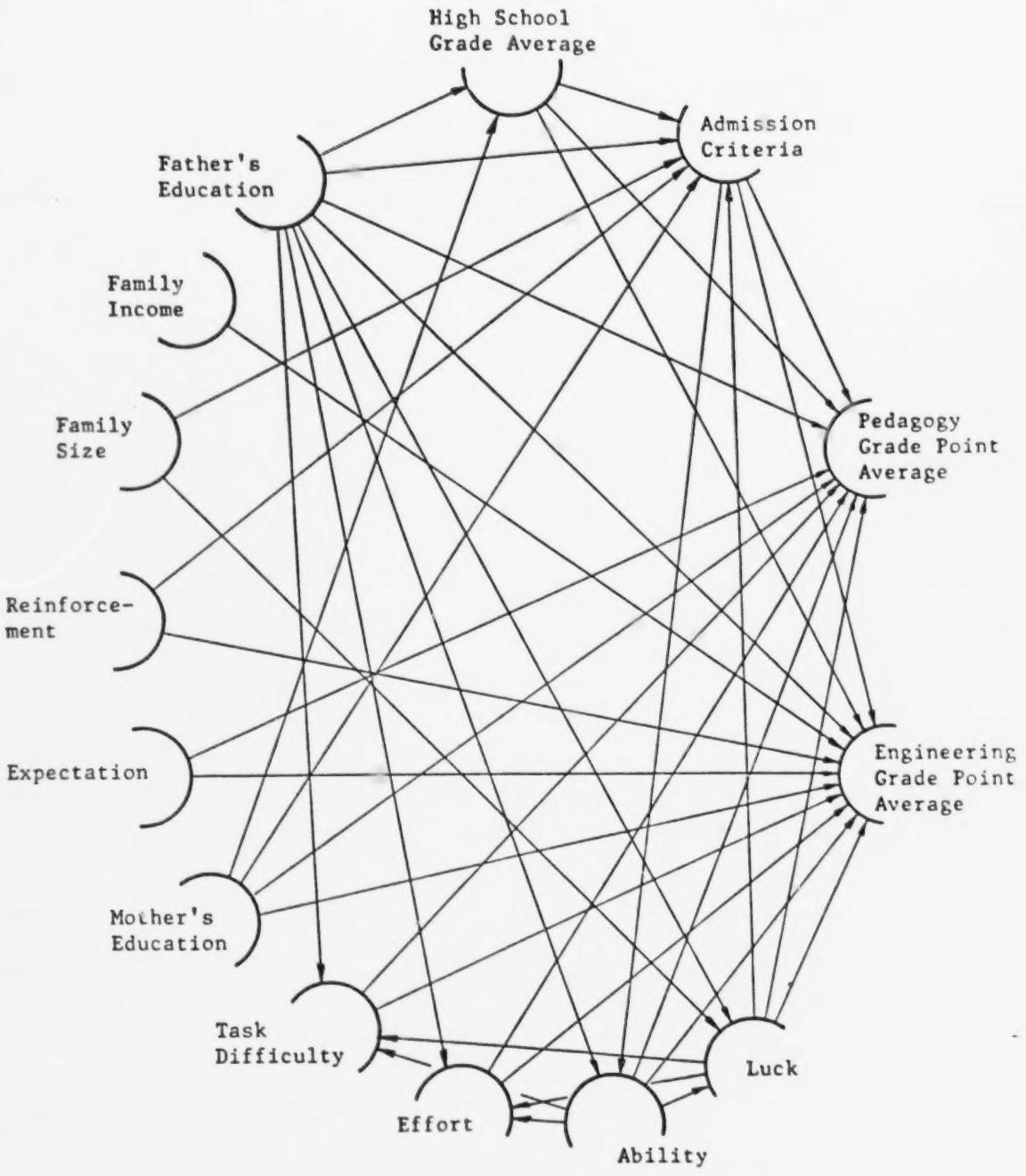

Figure 3. Thirty-Nine Significant Student Background Characteristics on Achievement of Technical Training Students Identified by Path Analysis

Table 5

Residual and Squared Multiple Correlation (SMC) of Parameter Estimates by Covariance Structural Analysis with Indirect Observation Variables

Parameter	Residual	SMC
Latent variables		
Home condition	.619	
Cognitive entry behavior	.300	.234
Attribution of success and failure	.400	.026
Observable variables		
High school grade average	.608	.392
Admission criteria	.930	.070
Ability	.589	.411
Task difficulty	.720	.280
Effort	.675	.325
Luck	.850	.150
Pedagogy GPA	.659	.341
Engineering GPA	.006	.994
Father's education	.388	.612
Mother's education	.381	.619
Family income	.935	.065
Family size	.954	.046
Reinforcement	.838	.162
Expectation	.858	.142
Criterion		
College academic achievement	.300	.698

Total Coefficient of Determination of Structural eq. = .503
Total Coefficient of Determination for X Variable = .735
Total Coefficient of Determination of Y Variable = .997
Goodness of Fit Index = .921
Adjusted Goodness of Fit Index = .888
Root Mean Square Residual = .088

elements, in this case equal to one; there was at least one nearly perfect relationship among observable variables. In such a case, Joreskog & Sorbom (1984) suggest the unweighted least square method of estimation.

The goodness of fit index was .921, the adjusted goodness of fit .888, and the root mean square residual .088 (see Table 5). The goodness of fit index is a measure of the relative amount of variance and covariance jointly accounted for by the model.

Based on this information, the modified model, analyzed by covariance structural analysis with indirect observation, fit the sample data very well. Thus, analysis met all the criteria for rejecting the null hypothesis. Therefore, the null hypothesis of no difference between the model (population matrix) and data (sample matrix) was rejected. In short, the model provided a reasonable and powerful array of variables for predicting the academic achievement of teacher trainees in the technical institutes of Padang and Yogyakarta. The total coefficient of the determination of X is a generalized measure of reliability for the whole measurement model for predictor variables. This coefficient was high (.735) indicating that the measurement model for joint predictor variables was very good. The total coefficient of the determination of Y (intervening and criterion) variables is a generalized measure of reliabililty for criterion variables. In this case, Y variables consist of high school grade average, admission criteria, ability, effort, task difficult, luck, pedagogy GPA, and engineering GPA. The reliability of the measurement model for criterion variables was found to be remarkably high (.997) indicating that the measurement model of criterion variables was excellent.

The latent variable model accounted for 70% of the variance in college academic achievement (see Table 5), 23% of the variance in the cognitive entry behavior, and 7% of the variance in the attribution of success and failure. Factor loadings for parameter estimates of observable variables encompassed within each latent variable developed through LISREL's covariance structural analysis are identified in Table 6. The model's graphic depiction appears in Figure 4.

Table 6

Factor Loading on each Latent Variable of Parameter Estimates by Covariance Structural Estimates

Latent Variable	Observable Variable	Factor Loading
Cognitive entry behavior	HSGA	1.000
	Admission criteria	.423
Attribution of success & failure	Ability	1.000
	Effort	.890
	Task difficulty	.826
	Luck	.605
Home condition	Mother's education	1.000
	Father's education	.994
	Reinforcement	.571
	Expectation	.480
	Family income	.325
	Family size	.272
College academic achievement	Engineering GPA	1.000
	Pedagogy GPA	.586

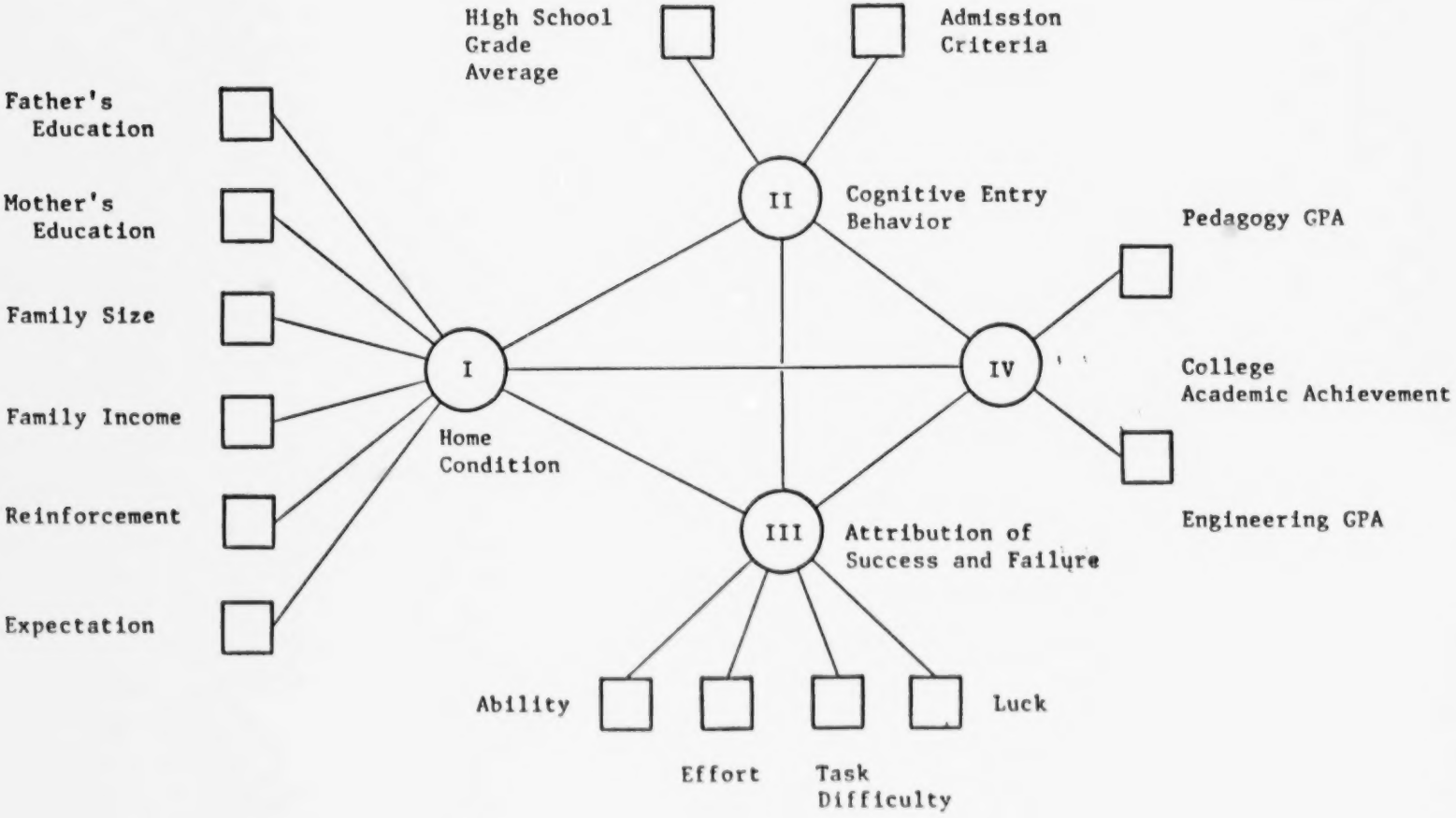

Figure 4. Model Assessed by Covariance Structural Analysis with Latent Variable

Conclusion

The model with latent variables was a powerful predictor of college academic achievement, accounting for 70% of the variance. It was less efficient in accounting for cognitive entry behavior or attribution of success and failure. The better showing for college academic achievement and cognitive entry behavior may be due to the greater stability of these measures compared to the latent variable attribution of success and failure. However, the primary interest of developing and validating this model within the Indonesian setting was to predict student achievement at technical teacher training colleges. In this respect, the model was very effective.

The model and empirical evidence have demonstrated clearly the importance of cognitive entry behavior, home condition (a combination of socioeconomic status and family educational environment), and attribution of success and failure. The study illuminated the rather complex process by which the effect of home condition on college achievement is mediated by student perceptions and beliefs (the attribution of success and failure) and toward their psychological experiences (cognitive entry behavior). Most noteworthy of these are the rather sizable contribution of mother's and father's education on home condition.

The model was conceived as an application of cognitive theories well described by Bloom (1976), Kohn's social theories (1969), the bio-social theory of Williams (1976), and theory of

attribution formulated by Weiner (1979). Empirical data confirmed the model's deductive formulation. Thus, the model was a reasonable synthesis of the four theories. This finding exists in spite of potential limiting factors such as (a) application of the constructs within a different cultural setting, (b) a narrowly defined educational population, and (c) instrumentation of marginal reliability for one construct.

The data analysis techniques offered a powerful tool for the investigation. The criteria established for the path analysis provided confidence that the second phase of the analysis, LISREL, could be reasonably applied. Second, the path analysis provided evidence which permitted modification of the model, without reformulating the basic tenets or assumptions critical to the model.

Finally, the study attended to important concerns in Indonesia. Information was provided about the current admission criteria which included two options: an entrance examination or talent scouting which was a form of ranking high school students. The two options were combined in the model and constituted the variable "admission criteria." In the model, this variable explained only 9% of the variance of the construct college academic achievement. By contrast the single variable high school grade point average explained 35%. Thus, the study provided substantial evidence that the Indonesian admission policies needed to be reviewed.

In sum, the study shed new insight about predictive relationships where psychological and sociological constructs

are combined; it successfully applied a new and powerful statistical tool; and it provided valuable planning information for Indonesia's teacher training system.

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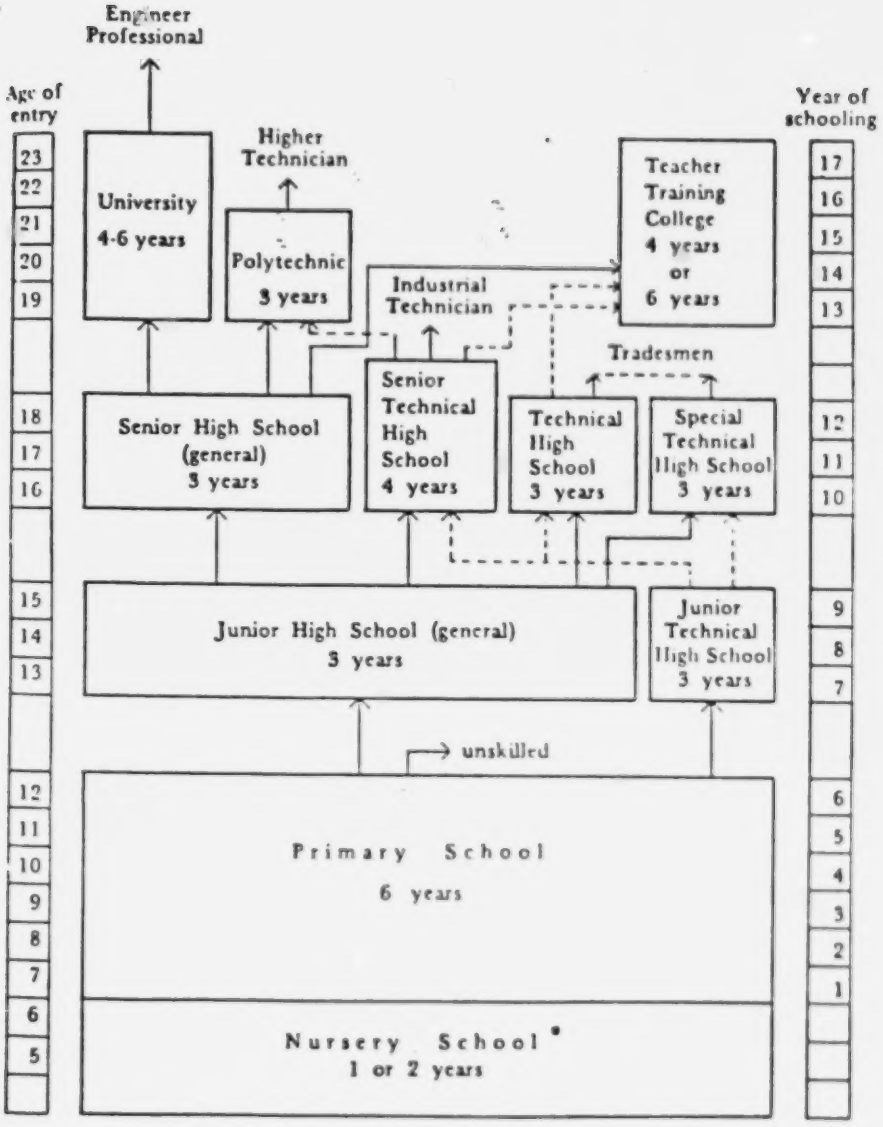
Appendix A

Indonesian Educational System



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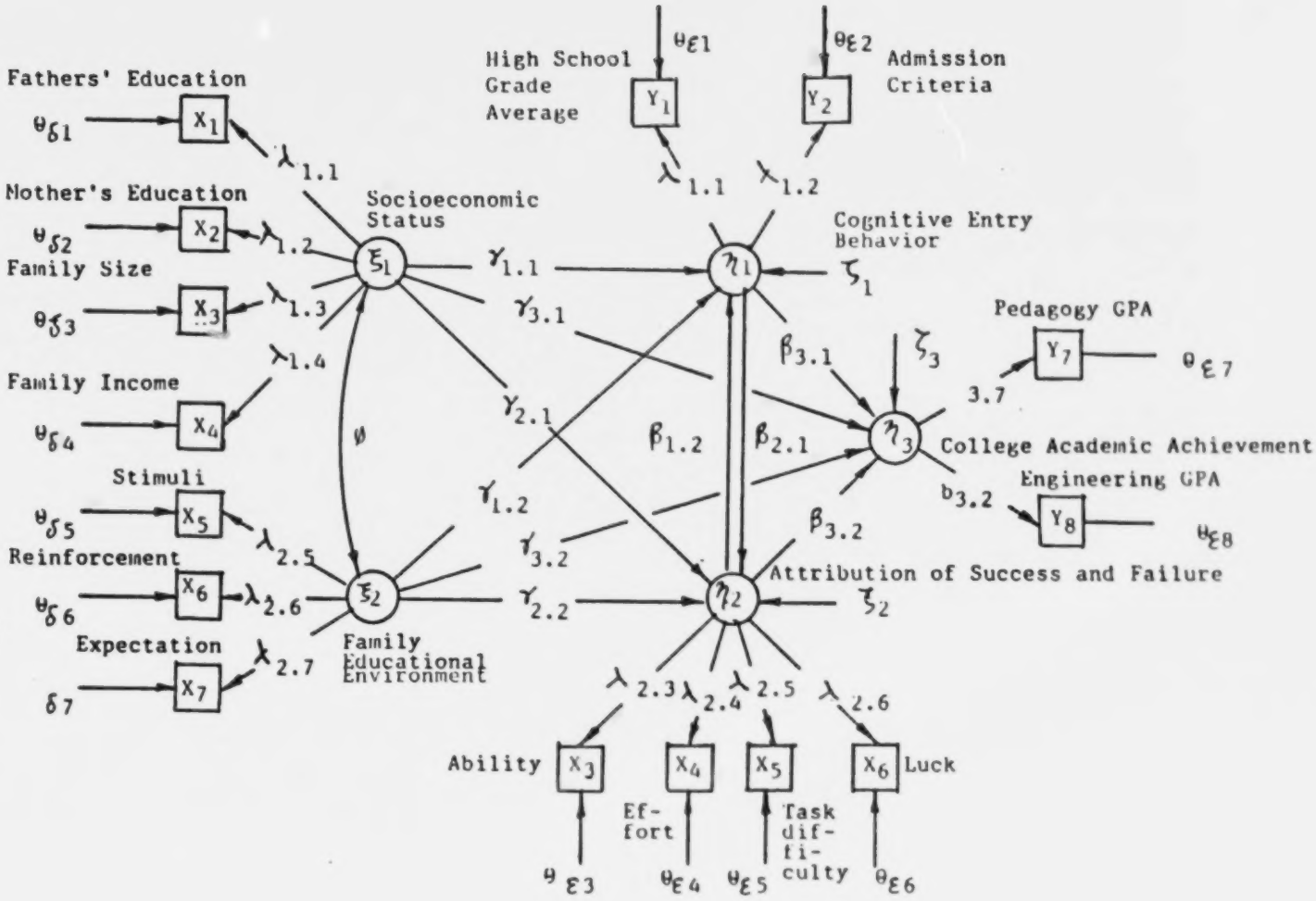

Figure 1. Model for Predicting College Academic Success

(θ_{ij} = Measurement error in observable variable; ζ_i = Measurement error in latent variable; $\lambda_{i.j}$ = Factor loading; ϕ = coefficient correlation; $\gamma_{i.j}$ and $\beta_{i.j}$ = Regression weight)

Appendix B

Notations for Model Designed to Predict College Academic Achievement from Background Characteristics

Description of the variables. Four observable variables (father's education, mother's education, family size, and family income) comprise the latent variable of socioeconomic status.

Three observable variables--stimuli provided, reinforcement offered by parents, and the effect of parental expectations on the child's educational levels--make up family educational environment.

Two variables, high school grade average and admission criteria, comprise cognitive entry behavior. High school grade average represented the average scores of students over three-year periods at the senior high level (either in a general high school or in a technical-vocational school). The admission criteria used were either high school rank or entrance examination scores.

Four variables--ability, effort, task difficulty, and luck--comprise the variable of attribution of success and failure.

Two variables, pedagogy and engineering GPAs, comprise the college academic achievement variable. Pedagogy and engineering GPAs were measured from the sophomore to senior levels.

The subsequent discussion explains how this concept was transformed into a mathematical approach in order to analyze this conceptual model.

The measurement model for dependent variables is:

$$\underline{Y} = \underline{\lambda}_y \underline{\eta} + \underline{\theta}_\epsilon \quad \ldots\ldots\ldots\

measurement error in predicting observable variables is given in vector $\underline{\theta}_{\epsilon}$.

The measurement model for independent variables is:

$$\underline{X} = \underline{\Lambda}_x \underline{\xi} + \underline{\theta}_{\delta} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (2)$$

The $\underline{\Lambda}_x$ (lambda-x) are factor pattern matrices containing the regression of x on exogenous variables ($\underline{\xi}$, ksi). The measurement error in predicting the independent measured variable is given in vector $\underline{\theta}_{\delta}$.

Finally, the structural equation model is:

$$\underset{\sim}{\eta} = \underset{\sim}{\beta}\,\underset{\sim}{\eta} + \underset{\sim}{\gamma}\,\underset{\sim}{\xi} + \underset{\sim}{\zeta} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (3)$$

The hypothesized direct effect of the exogenous latent variables ($\underset{\sim}{\xi}$) on the endogenous latent variables ($\underset{\sim}{\eta}$) is presented by $\underset{\sim}{\gamma}$ (gamma). Each row of $\underset{\sim}{\gamma}$ contains the regression of specific endogenous latent variables ($\underset{\sim}{\eta}$) on each exogenous latent variable ($\underset{\sim}{\xi}$). The hypothetical direct effects among the endogenous latent variables are shown by $\underline{B}$ (beta). The assumptions of those structural equations are:

- $\underset{\sim}{\zeta}$ is uncorrelated with exogenous latent variables ($\underset{\sim}{\xi}$).
- $\underset{\sim}{\epsilon}$ is uncorrelated with endogenous latent variables ($\underset{\sim}{\eta}$).
- $\underset{\sim}{\delta}$ is uncorrelated with exogenous latent variables ($\underset{\sim}{\xi}$).
- errors of measurement are assumed to be uncorrelated with $\underset{\sim}{\eta}$, $\underset{\sim}{\xi}$, and $\underset{\sim}{\zeta}$ but may be correlated with others.

Notations

- $\underline{Y}$ represents the dependent measured variable;
- $\underset{\sim}{\lambda}_y$ (read lamda-y) stands for the factor loading of dependent measured variables on the endogenous latent variables ($\underset{\sim}{\eta}$);
- $\underset{\sim}{\eta}$ (read eta) is the endogenous latent variable;
- $\underset{\sim}{\xi}$ (read ksi) is the exogenous latent variable;
- $\underline{X}$ represents the independent measured variable;
- $\underset{\sim}{\gamma}$ (gamma) is the direct effect of the exogenous latent variable on endogenous latent variables;
- $\underset{\sim}{\lambda}$ (lamda) equals the regression coefficient of the latent variable on measured variables;
- $\underset{\sim}{\epsilon}$ (epsilon) is the vector of measurement error in dependent measured variables ($\underline{Y}$);
- $\underset{\sim}{\delta}$ (delta) is the vector of measurement error in independent measured variables ($\underline{X}$);
- $\underset{\sim}{\zeta}$ (zeta) is the vector of measurement error in endogenous latent variables ($\underset{\sim}{\eta}$);
- $\underline{\Theta}_\epsilon$ and $\underline{\Theta}_\delta$ are the covariance matrices of $\underset{\sim}{\epsilon}$ and $\underset{\sim}{\delta}$;

Five latent variables (circles) and 15 measured variables (squares) are intercorrelated as shown in Figure 1.

If X_1, X_2, X_3 and X_4 represent father's education, mother's education, family income, and family size, $\underset{\sim}{\eta}_1$ might be hypothesized as quantitative factors of socioeconomic status. A similar rationale can be used for family educational environment and the attribution of success and failure. The letters X_5, X_6,

and X_7 refer to the measured variables of family environment and represent stimuli, reinforcement, and expectation, respectively, while Y_3, Y_4, Y_5, and Y_6 represent the measured variables of ability, effort, task difficulty, and luck. Letters Y_1 and Y_2 represent high school grade average and admission criteria.

Figure 1 exhibits a figurematic arrangement of the variables discussed thus far, showing them as being implicated in a rudimentary model of the achievement variables. On the right is shown the ultimate outcome of the whole process; the respondent's academic achievement. The letter η_3 stands for the achievement variable as measured by GPAs in the substantive engineering course (Y_7) and pedagogy (Y_8). Five arrows lead to college academic achievement (η_3), representing the assumption that achievement depends directly on:

1. cognitive entry behavior (measured by high school grade average, and admission criteria; measured also by high school rank and entrance examination scores),
2. the attribution of success and failure (measured by effort, task difficulty, luck, and ability),
3. socioeconomic status (measured by the number of academic years of father's and mother's schooling, family income, and family size),
4. family educational environment (measured by stimuli and reinforcement provided by the students' parents, and by expectations held by the students' parents), and
5. unspecified residual factors.

A second relation depicted by the figure is the endogenous latent variable of ASF (η_2), dependent on:

1. cognitive entry behavior, η_1,
2. family educational environment, ξ_2,
3. socioeconomic status, ξ_1, as well as,
4. unspecified residual factors.

A final relation depicted by the figure is the dependence of college academic achievement on:

1. cognitive entry behavior, η_1,
2. the attribution of success and failure, η_2,
3. socioeconomic status, ξ_1,
4. family educational environment, ξ_2, and
5. unspecified residual factors.

Appendix C

DEFINITIONS

1. Stimuli: parents' encouragement of subjects to learn
2. Reinforcement: parents' efforts to motivate subjects to learn
3. Parental expectations: parents' expression of subjects' education goals
4. Level of father's education: years of schooling
5. Level of mother's education: years of schooling
6. Family income: Indonesian currency, Rupiah
7. Family size: number of people supported by the parents
8. Ability: subjects' perceptions of their academic capacity
9. Effort: subjects' perceptions of their effort learning
10. Task difficulty: subjects' perceptions about requirements to achieve a task
11. Luck: subjects' beliefs that luck affected their success
12. Admission criteria: high school rank or entrance examination scores
13. High school grade average: subjects' high school grade point average for all courses over three years
14. Pedagogy grade point average: subjects' college achievement in pedagogy
15. Engineering grade point average: subjects' college achievement in engineering